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DSTL, AVIA 18/4229, 9 Jul 2008

21st Part of No. AAEE/875/1.

MINISTRY OF SUPPLY

AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT

BOSCOMBE DOWN

PROVOST T. MK.1 WV.418
(LEONIDES 126)

HANDLING TRIALS ON THE FIRST PRODUCTION AIRCRAFT

AAEE Form 1. 5/52 (A1513) Wt.33812/798. 40M. 2. 2/53. H. E. & S. Gp.848

21st Part of Report No. AAEE/875/1

AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT
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2?.??.1953

Provost T Mk.1 WV.418
(Leonides 126)

Handling trials on the first production aircraft

A. & A.E.E. Ref.: AAEE/5714,e/1/EO.
Period of Test : 2nd - 30th March, 1953.

Progress of issue of Report

Report No.	Title
16th Part of AAEE/875/1.	WE.530 Longitudinal stability and manoeuvrability measurements with an increased elevator inertia weight.
17th - do -	WE.530 Radio acceptance trials.
18th - do -	WE.421 & 422. Comparative assessment of lighting systems.
19th - do -	WV.418 Engineering appraisal of Leonides engine installation.
20th - do -	WV.418 Inverted flight tests on a 1st production aircraft.

Summary

The results of tests undertaken on Provost T. Mk.1 WV.418, the first production aircraft, disclosed little difference in the handling characteristics from those of the prototype previously tested and the aircraft is considered satisfactory.

However, in view of the forward movement of the practical c.g. limits on production aircraft, it is recommended that a check should be included in the Firm's flight test schedule to ensure that there is sufficient elevator trimmer capacity to meet the requirements of AP.970.

This report is issued with the authority of

Air Commodore,
Commanding, A. & A.E.E.

/Introduction....

1. Introduction

This report contains the results of qualitative handling trials made on Provost T. Mk.1 WV.418, the first production aircraft.

2. Condition of aircraft

2.1. General. The aircraft was aerodynamically similar to the prototype Provost WE.530, described in earlier parts of this report.

The static pressure vents had been repositioned approximately 6 inches higher on the fuselage than the position described in the 11th part of report A&AEE/875 (P.56 prototype). This modification was the result of repositioning the aircraft's internal equipment, made in order to achieve the practical c.g. limits recommended by this Establishment.

Other details and the flying limitations relevant to the tests are given in Appendix 1.

2.2. Loadings. The aircraft was flown from the following take-off loadings.

(i) Weight 4380 lb., C.G. position 26.3 ins. aft of datum (29.0% S.M.C)
(ii) Weight 4180 lb., C.G. position 25.7 ins. aft of datum (28.2% S.M.C)

These loadings were achieved without any special ballasting and represented the typical service load for the trainer role with pilot and pupil (loading 1) and pilot only (loading 2).

N.B. The datum point has been repositioned on production aircraft approximately 2 inches aft of the original position on the prototype.

3. Scope of tests

These trials, with the exception of an assessment of the trimmer capacity at loading 2, were limited to qualitative assessment of the handling characteristics at loading 1 only, since previous experience on the type had shown negligible differences in the characteristics at the practical forward and aft c.g. positions.

The tests, which were similar to those made on the prototype WE.530 and reported in the 7th and 10th parts of this report, included the following.

(i) Ground handling.
(ii) Take-offs and initial climb.
(iii) Stalling and spinning.
(iv) In-trim and out-of-trim dives.
(v) Aerobatics.
(vi) Landings and baulked landings.
(vii) An assessment of the longitudinal, lateral and directional trim, stability and control characteristics at certain flight conditions throughout the speed and engine power range.

4. Results of tests

4.1. General. The results of the tests disclosed little difference in the handling qualities from those of the prototype previously tested, the results of which were reported in the 10th and 12th parts of this report. The following remarks are therefore limited to where the characteristics differed from those previously experienced and to where criticisms were originally made on the prototype aircraft.

/4.2....

4.2. Stalling characteristics. The behaviour of the aircraft at the straight stall was an improvement compared with that previously experienced on the prototype. With power off, flaps retracted and fully down, there was ample stall warning and the stall consisted of a gentle nose down pitch with a tendency for either wing to drop, which could be held with coarse use of aileron providing no great degree of bank developed; even with full up elevator the aircraft could be held in a stalled glide using coarse aileron and rudder to prevent a wing dropping.

With "power on", there was slight and inadequate stall warning in the form of tailplane buffet about 1 knot above the stall, which occurred at 52 knots, I.A.S. with flaps fully down, power setting 2700 r.p.m., - 4 lb/sq.in. boost. At the stall there was a tendency for either wing to drop which again could be corrected using coarse aileron and rudder but it was found at this lower airspeed that there was a tendency to overcorrect due to the ailerons overbalancing after approximately half travel. The stick forces required to prevent overbalance occurring were very light.

The indicated air speeds at the stall were approximately 2 - 3 knots higher, power on and power off, than those reported in the 12th part of this report.

The characteristics of the stall in turning flight were similar to the prototype.

4.3. Spinning characteristics. A spinning programme was carried out involving 3 and 8 turn spins to the left and right from straight stalls, power off, and 3 turn spins to the left and right from turning flight, power on and off. The method of entry and original trim conditions were similar to those reported in the 12th part of this report.

The behaviour during entry, and in the incipient spin, was similar to that previously reported but once in the stabilised spin it was found that the spin to the right was considerably rougher than the spin to the left with marked variations in the rate of roll and yaw and slight variation in the rate of pitch.

On effecting reverse recovery procedure after 3 turns of a spin to the left, i.e. moving the stick forward and then applying full opposite rudder, the stick force required to apply full down elevator using one hand was just within the pilot's capabilities but it was not possible to prevent the stick moving away from the axis of the spin. Before opposite rudder was applied the spin steepened and roughened and the ailerons could then be centralised. Recovery was not effected until opposite rudder was applied.

On attempting reverse recovery procedure in a spin to the right the pilot could again apply full down elevator but in this instance it was possible to hold the ailerons central using a heavy aileron force. Recovery did not occur until full opposite rudder was applied.

All other characteristics of the spin, including the effect of engine and of applying aileron in and out of the spin, were similar to those previously noted on Provost WE.530 and reported in the 12th part of this report.

4.4. Longitudinal characteristics

4.4.1. Adequacy of trimmer capacity. Previous tests on the prototype had disclosed a partial trim tab stall at extreme deflections, with a resultant lack of nose up trimmer capacity at the forward c.g. positions, with power off. To assess the trimmer capacity in relation to AP.970 requirements, full nose up trimmer movement was applied at loading 2 and the trim speeds (hands off) noted, with the engine at idling r.p.m., flaps retracted and flaps fully down. The aircraft was then stalled in those configurations. The results were as follows:

/(a)....

(a) Flaps retracted

Stalling speed 70 knots I.A.S., Trim speed 79 - 82 knots I.A.S. fluctuating (1.14 - 1.17 V_{s_1}).

(b) Flaps fully down

Stalling speed 65 knots I.A.S., Trim speed 71 - 72 knots I.A.S. (1.09 - 1.11 V_{s_2})

4.4.2. Out of trim dives. The aircraft was trimmed to fly level at 4,000 ft., using 2600 r.p.m., zero boost, at 125 knots I.A.S. The aircraft was then climbed to 8,000 ft. and a dive commenced. The elevator stick forces required to hold the aircraft in the dive at the relevant airspeeds were:-

12 lb. at 220 knots I.A.S.
20 lb. at 235 knots I.A.S.
24 lb. at 250 knots I.A.S. at 4,000 ft. approximately.

On release of the controls a maximum accelerometer reading of 3.5 'g' was noted.

4.5. Lateral and directional characteristics

4.5.1. General. The tests carried out on the prototype aircraft to assess the trim, control and stability characteristics, and listed in para. 4.5. of the 10th part of this report, were repeated on this aircraft with similar results, the only differences being indicated below. Though the engine boost limitation for maximum continuous power had been increased to $+4\frac{1}{2}$ lb/sq.in. from $+3\frac{1}{2}$ lb/sq.in. the latter power setting was used for the climb case in these tests in order that a more realistic comparison could be obtained with the previous tests.

4.5.2. Straight sideslips. The aileron self-centering characteristics on release of the controls during sideslips were poor at the lower airspeeds but there was no deterioration from the standard tested on the prototype WE.530, reported in the 12th part of this report.

It was noted during sideslips on the climb, using power setting 2900 r.p.m. $+3\frac{1}{2}$ lb/sq.in. boost, that the rudder forces commenced to lighten off after $\frac{3}{4}$ - $\frac{7}{8}$ travel but remained positive up to full displacement. This was the only flight condition in which there was any tendency for the rudder forces to lighten.

4.5.3. Rates of roll. The rate of roll was measured at various airspeeds using,

$\left.\begin{array}{l}\text{(a) aileron, rudder fixed central}\\ \text{(b) aileron, assisting the roll with rudder.}\end{array}\right.$

(a) aileron, rudder fixed central
and (b) aileron, assisting the roll with rudder.

In all cases conventional elevator was applied to prevent the aircraft's nose dropping during the roll.

The aircraft was banked to about 45° then full opposite aileron was applied and the roll timed through 360° from wings level. The time taken for the rolls in either direction at the various airspeeds are tabulated below.

I.A.S. (knots)	Time through 360° (secs.)			
	Aileron and elevator only		All three controls	
	Left	Right	Left	Right
100	5.8	5.6	5.5	5.5
140	5.3	5.4	5.0	4.5
180	4.4	4.6	4.2	4.4
200	4.4	4.5	4.0	3.9

/4.6....

4.6. Landings. The characteristics of power on and glide approach landings into wind were similar to those previously reported in the 10th part of this report.

It was noted during crosswind landings, with crosswind components in excess of 12 knots, that there was a tendency to ground loop during the ground run, due to the "weathercock" stability of the aircraft and differential braking was required to prevent this. Such landings were made on the concrete and grass runways under rainy conditions but at no times were difficulties encountered as a result of the wheels slipping on the wet surfaces.

5. Discussion of results

5.1. General. The results of these tests disclosed little difference in the handling qualities from those noted on the prototype WE.530, previously reported in the 7th, 10th and 12th parts of this Report. However, the following features arise as a result of these tests which warrant further comment.

5.2. Spinning. The characteristics during the spin differed from those noted on the prototype WE.530 (12 part) in that the spin to the right now resembled that previously experienced in a spin to the left, and vice versa. This change is considered attributable to variations of wing leading edge profile, etc. and such differences are to be expected between production aircraft.

Though it was possible to recover from the spin using reverse recovery procedure the behaviour of the aircraft was considered sufficient to deter any pupil from using this incorrect method of recovery.

5.3. Adequacy of trimmer capacity. The assessment of the trimmer capacity at the practical forward c.g. position showed that there was sufficient available nose-up trimmer movement despite the forward movement of the practical c.g. range on production aircraft. With the gain in stick free static stability, attendant on an increased elevator weight effect (see 16th part of this report), it was possible to set the port balance tab more positive than the -4° originally recommended thus increasing the available nose-up trim range.

The qualitative assessment of the longitudinal characteristics had shown the stick free static stability to be satisfactory on this aircraft and comparable with that of the prototype WE.530 (reported in the 11th part), therefore, the setting of the port balance tab at -2° is now considered acceptable.

It should be noted that, though it is now possible to reset the port balance tab to a more positive value than originally recommended, progressive alteration in that direction produces a reduction in stick free static stability, therefore, the port balance tab settings should be limited so that there is no deterioration in static stability from the standard measured on the prototype, reported in the 11th part of this report.

5.4. Aileron characteristics. In order to counteract heaviness of the ailerons at extreme deflections, reported in the Firms flight test report (R.T.O. ref. 15167, dated 3.3.53), the aileron up movement was restricted and the balance tab gearing increased slightly. This has resulted in a decrease in the rate of roll throughout the airspeed range of the order of 8°/sec. compared with WE.530. On the prototype, assisting the roll with rudder, when using full aileron, had negligible effect and a rate of roll of the order of 90°/sec. was obtained.

This reduction in the rate of roll is not considered detrimental to the role of the aircraft.

/5.5....

5.5. Stall warning. A previous criticism of this aircraft concerned the lack of stall warning with the hood open, power off and in all configurations, power on. In the first case the only period when the lack of stall warning would prove an embarrassment would be during the power off approach to land and the logical conclusion is that all such landings should therefore be made with the hood closed and a suitable clause recommending this included in the relevant section of Pilot's Notes.

Regarding the lack of stall warning with power on, it was stated that further developments were being undertaken with a view to fitting artificial stall warning; the merits of this were discussed in the 12th part of this Report. This aircraft was not fitted with such a device and it is now understood that, unless training requirements finally warrant the inclusion of this device, it is not intended to provide artificial stall warning.

It is still the opinion of this Establishment that some form of stall warning should be provided on an aircraft of this role, since there is a likelihood of a pupil pilot losing control of the aircraft during a power-assisted approach as a result of a stall through not appreciating the change of aircraft attitude immediately prior to the stall.

5.6. Rudder lightening. The rudder lightening encountered during sideslips on the climb was very mild and the characteristics are, in this instance, considered satisfactory providing there is no further deterioration from the standard tested.

5.7. Crosswind landings. The tendency to ground loop commented upon in para. 4.6. should not prove disconcerting to pilots providing that they are fore-warned of it. It is therefore recommended that a suitable clause should be included in the relevant sections of Pilots' Notes.

6. Conclusions

The results of the tests disclosed little difference in the handling characteristics from those of the prototype previously tested.

However, in view of the forward movement of the practical c.g. limits, it is recommended that a check should be included in the Firm's flight test schedule to ensure that there is sufficient trimmer capacity to meet the requirements of AP.970.

Circulation List

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/Appendix 1....

Appendix I

1. Aircraft details and flying limitations

1.1. Control details

1.1.1. Elevator. The measured values obtained for the range of elevator movement was $+15^{\circ}$ to -28° 20' relative to the horizontal datum.

With the elevator at zero incidence the port plain balance tab was set at -2° 10' and the range of movement for the starboard combined trim and balance tab on trim alone was from $+16^{\circ}$ 13' (full nose up) to -9° 40' (full nose down).

1.1.2. Ailerons. The aileron up movement has been reduced from 25° to 20° and the aileron balance tab gearing increased slightly from 0.8:1 (aileron tab to aileron movement) compared with the prototype.

Measured values obtained on this aircraft were:-

Aileron movement port: up 19° 20', down 13° 5'.
starboard: up 19° 40', down 12° 45'.

Balance tab gearing port 1:1 starboard 1:1.08.

1.1.3. Rudder. Details of the rudder trim tab movement and surfaces were similar to those of the prototype P.56 aircraft, contained in the 2nd part of A&AEE/875.

1.1.4. Control circuit friction. The control circuit friction measured at the normal operating points were:

Elevator	2 lb.	(2)
Aileron	1 lb.	(4)
Rudder	4 lb.	(6)

The figures in parenthesis are the maximum values laid down in AP.970, Chapter 207, for this type of aircraft.

1.2. Flying limitations

1.2.1. Airframe. The following airframe limitations, extracted from the relevant R.D.(A) Form 13 dated 28.1.53, were applicable throughout the tests.

Maximum permitted airspeed	260 knots I.A.S.
Maximum permitted airspeed, flaps down	110 knots I.A.S.
Maximum permitted airspeed, hood open	120 knots I.A.S.
Maximum normal acceleration (attained in contractor's trials)	6 'g' at 220 knots I.A.S. at 5,000 ft., weight 4,200 lb.

The maximum permitted angle of sideslip, from design considerations, at the relevant airspeeds were

Angle of sideslip (deg.)	9.8	4.4
E.A.S. (knots)	174	260

The calculated angle at which the fin stalls was 18° (approx.)

1.2.2. Engine. The following engine limitations, quoted in A.P.4300 D, were observed.

/Take-off....

Take-off and operational necessity (5 min.)	3000 r.p.m., +8 lb/sq.in. boost
Maximum continuous	2900 r.p.m., $+4\frac{1}{2}$lb/sq.in. boost
Maximum weak mixture	2600 r.p.m., zero boost
Dive	3150 r.p.m.

N.B. The limiting boost for maximum continuous power has been increased from $+3\frac{1}{2}$ lb/sq.in. to $+4\frac{1}{2}$ lb/sq.in.

1.3. Test instrumentation. Test A.S.I., altimeter and Kollsman undamped normal accelerometer were installed in the cockpit. Stick forces were measured by means of a hand held stick force indicator of the "meat-hook" (spring balance) type.

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AD#: AD020258

Date of Search: 9 July 2008

Record Summary: AVIA 18/4229
Title: Provost T Mk 1 WV.418 (Leonides 126): Handling Trials on the First Production Aircraft
Availability Open Document, Open Description, Normal Closure before FOI Act: 30 years
Former reference (Department) 875/1 Pt 21
Held by The National Archives, Kew

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